A Field Manual of Scientific Protocols for Water Quality Surveys within the Upper Columbia Monitoring Strategy

2008 Working Version 1.0

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Section 1: Introduction

Columbia River Basin anadromous salmonids have exhibited precipitous declines over the past 30 years, with several populations now protected under the Endangered Species Act (ESA) (Schaller et al. 1999; McClure et al. 2002). A comprehensive monitoring strategy needs to be implemented to reduce the uncertainties surrounding the declines, and the strategies required to reverse this trend. Data collected from current and historical monitoring programs are generally not adequate or reliable enough for the purposes of ESA assessments and recovery planning (Tear et al. 1995; Campbell et al. 2002; Morris et al. 2002). In addition, monitoring programs for anadromous salmonids in the Columbia River Basin have typically been initiated to evaluate the effects of specific management actions, such as the demographic effects of hatcheries. As such, data are most appropriately viewed at the scale of the subpopulations and populations for which they were derived. However, the ESA requires assessments of species and their habitat at multiple spatial scales – from specific reaches, to subpopulations, populations, and the ESA management unit of Pacific salmon, the Evolutionary Significant Unit (ESU), which is a distinct population or group of populations that is an important component of the evolutionary legacy of the species.

Current monitoring programs for Pacific salmon did not develop as a cohesive design, thus aggregating existing data from many independent projects creates challenges in addressing these spatially complex questions. These problems arise because information is often not collected in a randomized fashion (Larsen et al. 2004), sampling techniques and protocols are not standardized across programs, and abundance, distribution, population dynamic, and demographic data for species and their habitat is often not available (Tear et al. 1995; Campbell et al. 2002; McClure et al. 2002). As recovery planning has focused more effort on tributary habitat restoration to mitigate for the mortality resulting from the Federal Columbia River Power System (FCRPS) the limitations of historic and ongoing sampling programs have become increasingly apparent.

The Integrated Status and Effectiveness Monitoring Program (ISEMP – BPA project #2003-0017) has been created as a cost effective means of developing protocols and new technologies, novel indicators, sample designs, analytical, data management and communication tools and skills, and restoration experiments. These tools are designed to support the development of a region-wide Research, Monitoring and Evaluation (RME) program to assess the status of anadromous salmonid populations, their tributary habitat, and restoration and management actions.

The ISEMP has been initiated in three sub basins: Wenatchee/Entiat, WA, John Day, OR, and Salmon River, ID, with the intent of designing monitoring programs that can efficiently collect information to address multiple management objectives over a broad range of scales. This includes:

• Evaluating the status of anadromous salmonids and their habitat;

• Identifying opportunities to restore habitat function and fish performance, and

• Evaluating the benefits of the actions to the fish populations across the Columbia River Basin.

This document was created as an internal guide for field practitioners working within Bonneville Power Administration's ISEMP during the 2008 field season. This water quality monitoring protocol follows monitoring recommendations made by the Draft Upper Columbia Monitoring Strategy (UCMS) (Hillman 2006). The UCMS outlines a monitoring strategy specific to the Upper Columbia Basin that follows monitoring approaches adopted by the Independent Scientific Advisory Board of the Northwest Planning council (ISAB), Action Agencies/NOAA Fisheries, and the Salmon Recovery Funding Board (SRFB). This approach includes monitoring current conditions (status monitoring), monitoring changes over time at the same sites (trend monitoring), and monitoring the effects of restoration actions on fish populations and habitat conditions (effectiveness monitoring).

This and other ISEMP protocols are being developed following the "Guidelines for Long-term Monitoring Protocols" (Oakley 2003). Many of the criteria listed in Oakley (2003) are contained in the UCMS (Hillman 2006), which can be viewed as a narrative for this and other ISEMP protocols. Questions of monitoring objectives, target populations, attribute selection, sample size, and sample design are all covered by the UCMS (Hillman 2006). However, the UCMS outlines a recommended approach to sampling design that is not always feasible. The adopted sample design may differ slightly from the UCMS to reflect 'on the ground' conditions and limitations, and these differences are described within the protocol. Although this is the first version of this protocol, water quality monitoring has been carried out in the Wenatchee and Entiat river subbasins since 2004 under the ISEMP program. All ISEMP protocols are updated annually, and do not change during the field season.

Although the UCMS identifies the project area as the Wenatchee, Entiat, Methow, and the Okanogan subbasins, this and other ISEMP protocols have only been implemented in the Wenatchee River and Entiat River subbasins. Monitoring in the Okanogan River subbasin is conducted by the Colville Tribe under the Okanogan Basin Monitoring and Effectiveness Plan (OBMEP) using protocols that have minor differences compared to the ISEMP protocols. A comprehensive and coordinated monitoring plan in the Methow River subbasin is under development.

Section 2: Sampling Design and Site Selection

This protocol is designed to standardize water quality monitoring procedures in the Upper Columbia Basin. The UCMS (Hillman 2006) serves as the primary reference for sampling designs at the basin and subbasin scale such as the selection of water quality parameters to be monitored and site selection. In addition, it may be appropriate to modify these sampling designs in order to address specific questions within any particular subbasin of the Upper Columbia Basin.

The seven water quality attributes identified by the UCMS (Hillman 2006) to be continuously monitored include temperature (weekly and daily maximums), turbidity, conductivity, pH, and dissolved oxygen (DO) at monitoring sites located at the downstream end of the distribution of each population or subpopulation, also known as integrator sites (Jordan 2003). The UCMS (Hillman 2006) also calls for seasonal measurements of nitrogen and phosphorous, achieved by collecting monthly grab samples at these same sites. Methods for continuous monitoring of attributes at integrator sites follow the manufacturers' guidelines for deployment and calibration, and are co-located with flow gauges operated by the United States

Geological Service (USGS) or Washington State Department of Ecology (WDOE). Coupling water quality monitoring stations with associated flow gauges allows investigators to assess the effect of stream flow upon the water quality attributes. The accuracies of the water quality instruments meet the Data Quality Level A as defined by the Oregon Watershed Plan Water Quality Monitoring Technical Guidebook (2001).

The immediate objective of water quality monitoring in the Wenatchee River subbasin is to determine the source and timing of elevated turbidity levels. Long-term sampling objectives are to determine the status and trend of these water quality metrics. Following the guidelines laid out in the UCMS (Hillman 2006), that one instrument should be placed at the downstream end of the distribution of each population or subpopulation for status and trend monitoring, the Cascadia Conservation District (CCD[1]) began year round continuous water quality monitoring and monthly nutrient sampling in 2004 at five integrator sites in the Wenatchee River subbasin (Figure 1), located near juvenile screw traps that monitor primary populations and subpopulations.

In addition to status and trend monitoring, water quality monitoring site locations in the Entiat River subbasin are designed to address Clean Water Act exceedences in pH. For these purposes, the USFS Pacific Northwest Research Station (USFS-PNW) uses the USGS National Water-Quality Assessment Program (NWQAP) approach, where a few points that integrate critical drainage areas are sampled intensively. This design facilitates definition of the spatial extent of pH exceedence. Furthermore, this approach corresponds well to monitoring targeted populations and subpopulations, or integrator sites, in the Entiat River and Mad River, the primary anadromous tributary in the Entiat River subbasin. One water quality probe is deployed at each of the stream gauging sites listed in Table 1. Sites are co-located with USGS or WDOE stream gauges to facilitate analysis of water quality-discharge relationships (McCormick and Woodsmith 2007).

The UCMS (Hillman 2006) calls for water quality effectiveness monitoring to be conducted, at a minimum, at the downstream end and at the upstream end of each reach that contains treatment or control sites. However, the UCMS recognizes that multiple treatment effects make it very difficult to assess the effects of specific actions and in the Entiat River there are many completed and proposed treatment actions that would make it difficult to asses them individually. Therefore, the UCMS (Hillman 2006) recommends monitoring at a larger scale where one can assess the combined or cumulative effects of treatment actions on the Recovery Unit, ESU, or population. To this end, ISEMP began funding an ongoing effort by the USFS to continuously monitor temperature at 30 sites in the Entiat River subbasin. The USFS began monitoring temperature at these sites in 1999, 4 years before any significant restoration actions were completed in the lower river, and thus 4 years of pre-treatment data exists. Funding ongoing temperature monitoring allows comparison of pre-treatment data to post-treatment data and allows managers to assess the cumulative effect of various restoration actions at the basin scale. Methods for continuous stream network temperature monitoring in the Entiat subbasin are based upon procedures outlined in the TFW Stream Temperature Module, Level 1 methodology (Shuett-Hames et al. 1999), with some departures as noted. The monitoring period was chosen to encompass expected low flows and the highest air temperatures for this area (early July to

[1] Formerly the Chelan County Conservation District

mid-Sept). In 2007, the monitoring period was extended at key sites to include the steelhead spawning period from March to May and the declining period of stream temperatures that typically occurs during the fall spawning period for Chinook salmon and bull trout. Thus, several temperature monitoring devices were in place from March to late December 2007 in the Entiat and Mad Rivers.

In addition to water quality monitoring in the Entiat, the USFS-PNW is collecting fish tissue and sediment samples for analyses to examine the presence, status, and extent of persistent biological contaminants in the food web of the Entiat River ecosystem (McCormick and Woodsmith 2007). The study results will provide a screening level assessment of the potential for adverse effects of toxic chemicals on aquatic biota and other wildlife. The organic contaminant study is not long-term monitoring and therefore is not included in this water quality monitoring protocol.

Personnel requirements and training

Each monitoring agency is responsible for training the personnel who will be deploying, checking and troubleshooting the water quality instruments, including water safety courses.

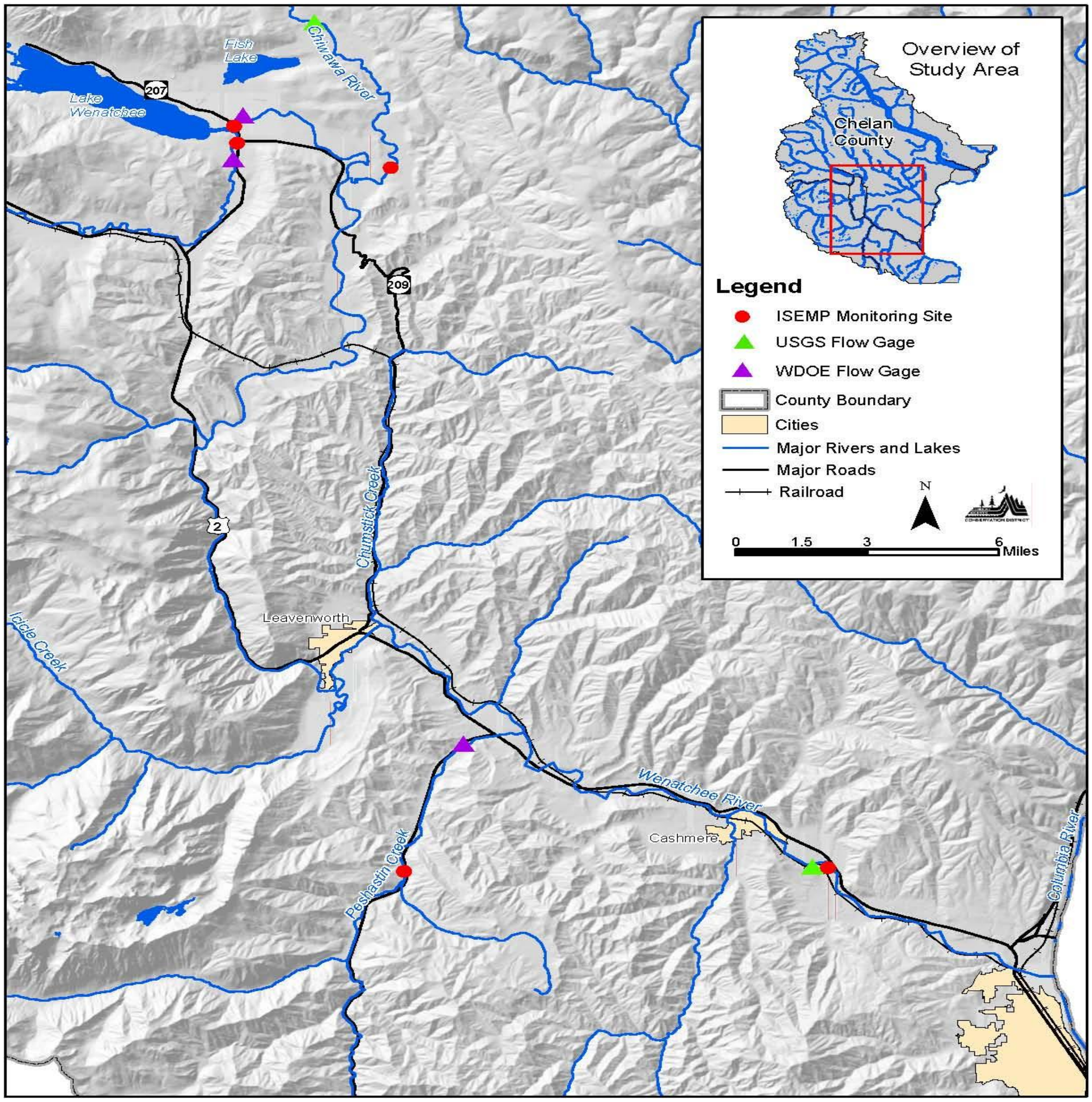

Figure 1. Location of ISEMP-funded monitoring sites and associated flow gauges in the Wenatchee River subbasin.

Table 1. Location of water quality probes in the Entiat River subbasin used for status and trend monitoring and to address Clean Water Act exceedences in pH.

River	Location	ID number	RKM
Entiat River	Near Entiat ("Keystone") USGS gauge	12452990	2.4 km
Entiat River	Near Ardenvoir ("Stormy") USGS gauge	12452890	29 km
Entiat River	North Fork Campground, WDOE[2]/CCD[3] gauge	46A170	58 km
Mad River	Mad River at Ardenvoir, USGS gauge	12452800	0.5 km

Section 3: Water Quality Monitoring Methods

Section 3.1: Status and Trend Water Quality Monitoring

References:

Hillman (2006); McCormick and Woodsmith (2007); Bookter and Woodsmith (2007).

Equipment:

Dataloggers and probes, reference probe, and field notebook or data sheets.

Concept:

In the Wenatchee River subbasin the CCD deploys Hydrolab Datasonde® 4 (currently being phased out), Minisonde 4, and Minisonde 5 water quality multiprobes to collect temperature, specific conductivity, pH, turbidity, and dissolved oxygen data at five locations (Figure 1). Furthermore, the CCD collects grab samples on a monthly basis to measure total phosphorous, dissolved phosphates, nitrate/nitrite ratios, total persulfate nitrogen, and ammonia. These samples are collected and sent to the EPA certified Cascadia Analytical Lab for analysis. Minimum detection levels of these nutrients are listed in Table 3.

Using ISEMP funding, the USFS-PNW began water quality monitoring in the Entiat River subbasin at four sites in 2007 using the In Situ Troll 9500 multiparameter probe. The probes continuously measure and log on an hourly basis temperature, specific conductivity, pH, and dissolved oxygen. The USFS-PNW calibrates the probes in the field since In-Situ sensors are designed for easy field calibration. This allows for calibration at the ambient temperature, elevation, and barometric pressure at the measurement site, thereby improving accuracy, and since the meters remain on site, interruption of data collection is minimized. Vented cables on these instruments measure real-time barometric pressure used to calculate dissolved oxygen values, thereby improving accuracy compared to fixed-pressure instruments. Turbidity has not been identified as a concern in the Entiat subbasin and USFS-PNW does not collect turbidity measurements at these sites (McCormick and Woodsmith 2007; Bookter and Woodsmith 2007).

In the Wenatchee and Entiat subbasins both types of probes are secured in the channel inside protective, four-inch diameter pipe, perforated at the probe location to ensure ample water circulation. All probes record water quality parameters at hourly intervals, allowing

[2] Washington State Department of Ecology
[3] Cascadia Conservation District

characterization of diel patterns. Accuracies are listed for each probe in Table 2 and meet or exceed U.S. EPA standards. Probes and batteries are inspected, adjusted, downloaded, and calibrated at intervals ranging from weekly to monthly, depending on instrument drift and personnel limitations. The CCD conducts downloading and in-lab calibration checks every 3 weeks. The 3 week interval was determined as the appropriate calibration period by reviewing past data (Carol Volk, ISEMP, pers. communication). The CCD collects monthly grab samples for lab analysis that is summarized in Table 3.

The value of these data sets will increase as the length of record increases and any conclusions drawn will become more robust as sampling continues. With longer data sets, extraordinary conditions that effect data, such as high flows or sediment loading, become less problematic. River ice in the winter may temporarily interrupt data collection to avoid damage to the probes.

Calibrated state-of-the-art water quality probes provide stable measurements that satisfy U.S. Environmental Protection Agency (EPA) data quality standards and are capable of long-term data logging, minimizing the cost of field crews relative to routine water quality sampling. Probes should meet the minimum accuracy requirements listed in Table 2, and be able to collect data hourly. Probes are either field calibrated or brought back to the lab for calibration and redeployed.

Table 2. Accuracies of Hydrolab and In Situ MP 9500 probes used for water quality monitoring under the ISEMP in the Wenatchee and Entiat subbasins.

Parameter	**Hydrolab Probe Accuracy**	**In Situ MP 9500 Accuracy**
Temperature	+/- 0.10 degrees Celsius	+/- 0.10 degrees Celsius
Specific Conductivity	+/- 0.001 mS/cm	+/- 0.002 mS/cm
pH	+/- 0.2 units	+/- 0.1 units
Dissolved Oxygen	Series 4 meters: +/- 0.2 mg/L for <20 mg/L +/- 0.6 mg/L for >20mg/L Series 5 meters (Clark's cell): +/- 0.1 up to 8 mg/L +/- 0.2 above 8 mg/L	+/- 0.1 mg/L for 0-10 mg/L +/- 1% of reading for 10-20 mg/L
Turbidity	1% up to 100 NTU 3% from 100-400 NTU 5% from 400-3000 NTU	Not Applicable

Table 3. Summary of laboratory measurements, methods, and reporting limits applied to water quality samples collected by the Cascadia Conservation District in the Wenatchee subbasin for the ISEMP.

Parameter	Method	Lower Detection Limit
Total Phosphorus	SM 4500P-D	0.01 mg/L
Dissolved Phosphates	SM 4500P-E	0.03 mg/L
Nitrate/Nitrite	SM 4500NO3-E	0.01 mg/L
Total Persulfate Nitrogen	SM 4500N-D	0.025 mg/L
Ammonia	SM 4500NH3-N	0.01 mg/L

Procedures:

Datalogger Deployment

Step 1: Calibrate each sensor in the lab or field, following the manufacturer's calibration procedures. Calibration procedures for In-Situ sensors can be found at www.in-situ.com. Calibration procedures for Hydrolab sensors can be found at www.campbellsci.ca/Products_Hydro.html. For improved accuracies, dissolved oxygen (DO) sensors should be calibrated at the sample site.

Step 2: For sensors that cannot be calibrated (e.g., temperature probes), conduct an accuracy check procedure according to manufacturer's instructions before deploying equipment. Temperature probe accuracy procedures are described in Section 3.2.

Step 3: Deploy equipment at secure sites that will have ample depth, turbulence and mixing, particularly at low flow. Avoid placing equipment in still water. If the probe is not in a pipe, locate the probe out of direct sunlight. Monument, GPS, and/or photograph the site sufficiently that it can be easily relocated, but not in a way that would bring attention to the probes. Secure the probe with rebar, cable, or weights as necessary.

Step 4: Record the date and time of deployment, personnel present, any unusual field conditions, battery voltage, data values present, and any results from field measurements.

Download data, calibration, and grab samples

Step 1: Return to sample sites to download data, conduct reference checks, and if necessary calibrate sensors.

Step 2: Collect grab samples by holding the container by the base, plunging the container mouth down below the surface of the water, and turning the container into the current upstream of the sampler. On the data form and on the sample jar itself record the date and time of sample collection and site name. Also record weather conditions and multi-probe readings of temperature, pH, specific conductivity, turbidity and dissolved oxygen at the time of data sample collection. Keep grab samples in a cool and dark place for delivery to the lab within 48 hours.

Step 3: If calibrating and downloading in the lab, pull the multi-probe and return to the lab. Calibrate in the lab following the manufacturer's procedures, and return probe to the field. Continue to step 7. The dissolved oxygen sensor must be calibrated at the sampling location.

Step 4: If field calibrating and downloading, conduct reference checks using a reference probe following these instructions (Bookter and Woodsmith 2007):

a. Allow reference instrument to equilibrate to the stream environment for a minimum of five minutes.
b. Record both field and reference instrument readings.
c. Compare the field and reference water quality readings.
d. If the difference between the field and reference readings is greater than the threshold deviations (Table 4), then the field sensor in question must be calibrated.
e. Sensor calibration may also be required under the following conditions:
   i) Consistent, repeated deviant trend in reference checks
   ii) Environmental disturbance to instrument (e.g., covered in fine sediment, biofouling)
   iii) Sensor parameters outside manufacturer recommended ranges.

Table 4. Acceptable calibration threshold deviation from the laboratory-calibrated reference instrument for field calibrating and downloading of data.

Variable	Threshold deviation
pH	±0.2 pH units
DO	±1 mg/L
Conductivity	±5 µS/cm
Temperature	±0.5º C

Step 5: Calibrations will be performed on field instrument sensors when indicated by reference checks. The calibration procedures for the In-Situ pH, conductivity, and optical dissolved oxygen (DO) sensors are available at www.in-situ.com and are described in Bookter and Woodsmith (2007).

Step 6: Calibrate the reference instrument before and after every day of reference checks. The pH and conductivity sensors are calibrated in the laboratory. A 2-point (pH 7 and 10) calibration is performed on the reference pH sensor before each field day. At the end of the field day, the complete 2-point calibration is unnecessary, so the pH sensor reading in pH 7 buffer solution is checked. If the end-of-the-day pH sensor reading deviates from the standard by more than 0.2 pH units (the pH sensor threshold deviation), the reference instrument pH readings for that day are noted as questionable. The conductivity sensor is calibrated before and after each field day with a 1-point calibration in a 147 µS/cm conductivity standard. Conductivity varies with temperature, hence the pre-calibration and post-calibration conductivities readings are compared to determine the sensor accuracy. If the pre- and post-calibration conductivities deviate by more than 5µS/cm, the reference conductivity readings for that day are noted as questionable (Bookter and Woodsmith 2007).

Step 7: At the lab examine the time series of all data for unusual patterns and values. Minor adjustments are applied to portions of some data series to correct for instrument drift, as indicated by reference checks and field calibrations. These data are labeled 'adjusted' in the database (see Carroll et al. 2006). Data of uncertain quality are labeled 'uncertain'. Uncertain data should be excluded from analysis, but not destroyed. Data are stored on the contractor's computers, and following QA/QC procedures, are provided to the BPA using ISEMP data management tools described in the Data Management section.

Field notes on data forms will be kept for each sampling event. Notes will be entered in a field notebook and include: date and time, sampling personnel, general sampling location, hand-held GPS latitude/longitude coordinates of probe locations, and appropriate results from field measurements.

Section 3.2: Entiat longitudinal temperature effectiveness monitoring.

References:

TFW Ambient Monitoring Program Stream Temperature Survey Module (Schuett-Hames et al. 1999), and Datalogger documentation.

Equipment:

Optic Stowaway Temp data logger (or equivalent), software, and downloading cable, PVC tubing, 1.5mm airline cable, 1 pound weight, NIST reference thermometer.

Concept:

In accordance with the Clean Water Act of 1977, which set federal standards for water quality, the State of Washington developed state standards to meet or exceed the CWA 303(d) list of federal standards, including standards for water temperature. Water temperature is a key component of fish habitat and aquatic ecology. Cold water fish species such as trout and salmon are particularly sensitive to very high and very low temperatures. Water temperature criteria set by the State (Class AA Streams <60.8ºF, Class A Streams <64.4ºF) and water temperature criteria set by the Wenatchee Forest Plan (<61ºF), focus mainly on summer maximum water temperatures. However, as postulated by the Entiat Watershed Analysis (WNF 1996), harsh winter rearing conditions could be more limiting than summer increases in stream temperatures within the Entiat and Mad Rivers. In order to describe water temperature reference conditions of streams and rivers within the Entiat and Chelan Ranger Districts and to evaluate water temperature conditions in CWA 303(d) listed waterbodies (e.g., mainstem Entiat River), a water temperature monitoring program was instituted by the USFS. In 1993 the Entiat Ranger District began monitoring summer maximum stream temperatures within the Entiat and Mad River watersheds and tributaries to Lake Chelan. In 1998, the stream temperature monitoring program was expanded and a network of continuous-recording thermographs was placed at multiple locations in the mainstem Entiat and Mad Rivers for an extended period of time (primarily late-March to early-November). This expanded network of stream temperature monitoring stations will be continued in order to provide information on the thermal regime of these watersheds and to contribute to efforts to describe reference conditions.

The UCMS (Hillman 2006) recommends that two temperature metrics serve as specific indicators of water temperature: maximum daily maximum temperature (MDMT) and maximum weekly maximum temperature (MWMT). Annual water temperature data are also used for multiple purposes, including the development of a regional database that may be used to revise Washington State temperature standards for Eastside streams, for future iterations of Watershed Analyses and Forest Plans to describe desired future conditions, to support the water quality element of the Entiat WRIA 46 Management Plan being implemented by the Entiat Watershed Planning Unit (EWPU) and CCD, and by District personnel in project analysis for proposed actions on National Forest lands, and in biological assessments for three ESA-listed species (bull trout, stream-type Chinook salmon and steelhead trout). The Entiat Ranger District data also supported SNTEMP model calibration of water temperature in the Entiat River (Hendrick and Monahan 2003) by providing observed water temperatures for the years 1995-2002. Longitudinal temperature monitoring of the mainstem Entiat River also allows for assessing the effectiveness of restoration projects to lower the maximum summer water temperatures.

This temperature monitoring program followed the procedures outlined in the TFW Stream Temperature Module, Level 1 methodology (Schuett-Hames et al. 1999) with some departures as noted. The monitoring period was chosen to encompass expected low flows and the highest air temperatures for this area (mid-June to mid-Sept). Since initiating the temperature monitoring program, the USFS has extended the monitoring period at key sites to include the steelhead spawning period from March to May and the declining period of stream temperatures that typically occurs during the fall spawning period for Chinook salmon and bull trout. Water temperatures during steelhead spawning are monitored at 6 stations in the Entiat River, and 3 stations in the Mad River (Table 5). Water temperature is currently monitored year round at five locations in the Entiat River, and at one location on the Mad River. Year round water temperature monitoring allows assessment of the effects of winter water temperatures on Chinook salmon egg survival and to predict times to emergence of fry. Gauges operated by the USGS or WDOE collect data continuously, year round, and are telemetered.

Stream temperatures monitored by the Entiat Ranger District include the Entiat and Mad Rivers (28 stations) within the Entiat Watershed (Table 5). The USFS used the Optic Stowaway Temp Datalogger® manufactured by Onset™ through 2006, and replaced all sensors with the Hobo U22 Water Tem Pro V2 also manufactured by Onset™. These temperature loggers record at minimum every 30 minutes and are accurate to ±0.2Cº. The Optic Stowaway Temp Logger has is accurate from -5Cº to 37Cº, and the newer Hobo U22 Water Temp Pro V2 is accurate from -20ºC and 70ºC. Additional stream temperature monitoring data is provided by the Entiat National Fish Hatchery (USFWS; RM 7.1) and the WDOE (RM 21.1, RM 26.0, RM 30.8, RM 33.6, and RM 34.1).

Procedures:

Site selection

Step 1: When establishing new water temperature monitoring stations follow the TFW Stream Temperature Module (Schuett-Hames et al. 1998). Locate temperature data loggers at the downstream end of the thermal reach, which is a reach that has similar stream and riparian conditions for a sufficient distance to allow the stream temperatures to reach equilibrium. Depending on the stream width, it takes between 300 and 600 meters of similar conditions to establish thermal equilibrium within a thermal reach. Take annual aerial photos of each site looking upstream to document stream reach conditions.

Data logger calibration and deployment

Step 1: Calibrate the Onset® Optic Stowaway Temp data logger using the procedure described in Figure 2. Alternatively, calibrate data loggers by simultaneously immersing a NIST thermometer and the data loggers into a warm (76 to 98ºF) bath for 30 minutes, stirring occasionally to reduce stratification. Repeat the procedure in a cold (60 to 64ºF) bath. Replace or send to manufacture for calibration all meters that are outside of the ±0.2ºC range from the reference thermometer.

The coffee mug logger test

The freezing point of water is 0°C (+32°F) with only a tiny dependence on pressure and the salt levels found in normal tap water. You can use this information to test the accuracy of your Optic StowAway Temp logger. Put crushed ice and water in an insulated container, and completely submerge the logger in the ice water with the sensor end down. Place the container in a refrigerator to minimize temperature gradients. Leave it in for fifteen minutes while logging to be sure the Optic StowAway reaches equilibrium. Offload the data and blow up the end of your plot to check the logger's accuracy. The actual temperature will be above 0°C, though less than 0.1°C if you do everything right.

This isn't really a coffee mug test because the logger won't fit into a standard one.

Four minute response time in water

Plot E shows that the temperature reached 90% of the step change in about four minutes.

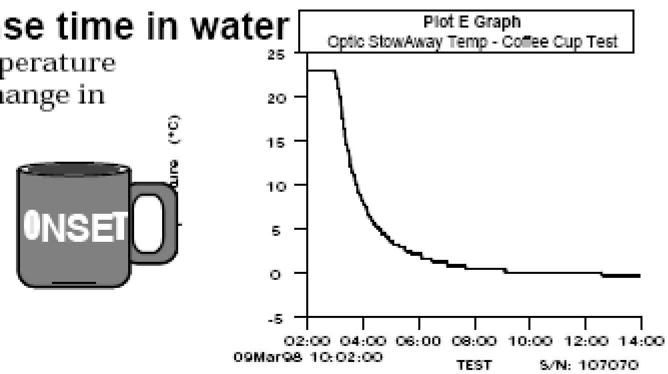

Figure 2. Manufacturer's suggested calibration procedure for the Optic Stowaway Temp data logger.

Step 2: Set the meter to record temperature every 30 minutes.

Step 3: Deploy meters in an open-ended PVC tube. Attach a weight to the bottom of the tube and secure the pipe and thermometer using airline cable, stainless steel cable, or chain. Secure the device to a tree or other stationary object. Alternatively, drive a fencepost and secure the thermometer to it. Deploying meters in this matter ensures that the meter case is not hit by substrate or debris, that sunlight does not reach the meter, and allows the meter to be deployed in deeper water thereby decreasing occurrences of dewatered devices.

Step 4: GPS the location of the data logger and record enough information to relocate it. Monument the location by placing a capped rebar or capped fencepost with the site ID, or select a tree as a monument tree and take a bearing from the tree to the data logger location and record the distance from tree to data logger. This ensures that the data logger can be easily retrieved.

Data logger retrieval and downloading

Step 1: Locate the data logger using the GPS and/or monuments. Record any unusual conditions or damage to the device. Return to the lab and download data according to manufacturer's instructions.

Step 2: Determine the accuracy of the temperature data by conducting a post-survey calibration to establish instrument consistency. If an instrument is between 0.5ºC to 2ºC off from the reference thermometer, qualify the data from the data logger as accurate to ± XºC degrees. If, through repeated measurements, it is found that an instrument is biased in one direction, consider adjusting the results from that data logger and label the data as 'adjusted'. Data of uncertain quality (e.g., more than 2ºC off from the reference thermometer) are labeled 'uncertain.' Uncertain data should be excluded from analysis, but not destroyed. Data are stored on the contractor's computers, and following QA/QC procedures, are provided to the BPA using ISEMP data management tools described in the Data Management Section.

Table 5. 2005 Entiat and Mad River longitudinal stream temperature monitoring stations, thermograph identities, river mile (RM), elevation, and approximate deployment period.

Elevation (ft)	Station	RM	Deployment period
744	Keystone Bridge[4]	1.4	June to October
820	Fire station (lower bridge)	3.2	June to October
950	Knapp Wham bridge	5.8	June to October
1050	Hatchery weir	7.1	March to October
1140	Powerline crossing	8.5	June to October
1250	Below Mad @ Coopers' Store	10.2	June to October
1265	Above Mad River	10.8	June to October
1365	Below Medsker Canyon	12.5	June to October
1480	Roundy Creek	15.0	June to October
1580	USGS Gauge near Stormy Creek[4]	18.0	March to October
1640	Dill Creek Bridge (WADOE guage 46A???)[5]	21.1	Year round
1710	Brennegan Creek	24.0	June to October
1750	Forest Boundary	26.0	Year round
2411	Silver Falls C.G.	29.5	June to October
2480	Tommy Bridge (WDOE gauge 46A150)	30.8	Year round
2600	Below Entiat Falls (WDOE gauge 46A160)	33.6	Year round
2650	@ North Fork Camp Ground (WDOE gauge 46A170)	34.1	Year round

[4] USFS has proposed that ISEMP contract with the USGS to add water temperature to the USGS gauging station at Keystone Bridge and Stormy Creek (currently monitored by the USFS). USGS water temperature gauges are operated year round, data is collected continuously, and are telemetered.

[5] Gauges operated by the WDOE are operated year round, collect data every 15 min., and are telemetered.

3080	@ Cottonwood Camp Ground	38.8	June to October
1300	Mad R @ Mouth		June to October
1400	Mad R. ^ Tillicum Cr		Year round
1650	Mad R. ^ Pine Flats		March to October
1850	Mad R. ^ Hornet Cr		March to October
2440	Mad R. ^ Windy Cr		June to October
3000	Mad R. ^ Young Cr		June to October
3400	Mad R ^ Cougar Cr		June to October
4100	Mad R. ^ Berg Cr		June to October
4600	Mad R. ^ Jimmy Cr		June to October
5400	Mad R. ^ Blue Cr.		June to October
5900	Mad R. @ Mad Lake		June to October

Section 4: Data Management

Data management framework

The ISEMP Data Management effort is designed to develop standardized tools and procedures for the organization, reduction, and communication of monitoring data and methods within ISEMP pilot basins located in the Wenatchee and Entiat subbasins, WA, John Day, OR, and Salmon River, ID. Beginning in 2004, a pilot project has been under development aimed at integrating four primary data management tools: Automated Template Modules (ATMs), the Status Trend and Effectiveness Monitoring Databank (STEM databank), Protocol Editor (PE), and the Aquatic Resources Schema (ARS). The STEM Databank is the central data repository for the ISEMP project. It was developed by the Scientific Data Management Team at NOAA-Fisheries to: (1) accommodate large volumes of data from multiple agencies and projects; (2) summarize data based on how, when, and where data were collected; (3) support a range of analytical methods; (4) develop a web-based data query and retrieval system, and (5) adapt to changing requirements. This fully-normalized database structure allows the incorporation of new attributes or removal of obsolete attributes without modification of the database structure. Data can be summarized in a variety of formats to meet most reporting and analytical requirements.

Successful data management systems require a user interface that is intuitive to the user and that increase the efficiency of the user's workflow. The Automated Template Modules (ATMs) are a collection of forms that allow users to enter and view data in a format that is familiar to biologists. Each ATM has forms for entering new data, reviewing existing data, and updating existing data. Additionally, each ATM has a switchboard to help guide the user to the correct forms.

The general layout of the forms includes a header section to display information about the data collection event and a series of tabs that display detailed observational data. The header section describes the general characteristics about when, where, and how the data was collected or observed. The header section always includes the site, the start date and time, and the protocol. Additionally, the header section may include general characteristics about the sampling reach or unit, environmental conditions, weather conditions, water temperature and visibility, presence of fish, and protocol deviations. A series of tabs below the header section display detailed observations that occurred during the data collection event in spreadsheet format. Tabs vary between the different ATMs, but typically include a tab for crew and for equipment.

Data entry forms perform the critical function of validating data at the time of data entry. For categorical attributes, users are only allowed to select from acceptable categories as defined by the protocol. Similarly, values entered for continuous attributes are checked to ensure values are within the expected range. Data entry forms are "protocol aware". The database includes tabular data that specifies details about the protocol. All categorical fields on data entry forms have pull-down lists that limit the values a user can enter for the field. The pull-down lists reference the protocol documentation tables and only display values that are defined for the active protocol. Similarly, for continuous values, the forms check the expected range as defined in the protocol and warn the user if the entered value falls outside of the expected range. Users can choose to modify the value or accept the value as it was entered. The use of "soft" bounds on continuous values is an effective validation strategy for ecological data, where data often follows a normal distribution with long tails as opposite to a discrete distribution common to financial data.

Protocol Editor is a data dictionary, user-friendly tool for describing the list of all attributes collected by a given protocol that includes a description of the data type, units of measure, number of characters or digits, number of decimal places, and list of acceptable values for all attributes collected by a protocol. Protocol Editor allows the ATM to be calibrated to a given protocol and allows the ATM to ensure consistency between the protocol and the data entered for that protocol. Protocol Editor follows the same rules established by Protocol Manager (a protocol documenting tool being developed by USBOR). A protocol is defined as a collection of methods, where each method consists of the list of attributes to be recorded by the data collector. The name of attributes is restricted to attributes defined by the ARS; however, users are allowed to create an alias name for the attributes. Metadata entered into Protocol Editor can easy be exported in a tabular format for importing into Protocol Manager.

The ARS is the collection of database tables that store data entered into the ATM forms. The ARS was developed to help agencies within the Columbia River Basin manage, document, and analyze aquatic resources data. The ARS aims to define a standardized data structure for storing and processing water quality, fish abundance, and stream habitat data. The ARS is robust against variations between data collection protocols, supports procedures for increasing data integrity at the time of data entry, and supports proper analysis and summarization of aquatic resources data.

Data handling

Data is to be recorded on the appropriate write-in-the-rain data forms and entered into a water quality ATM provided by ISEMP. The field practitioners should be careful to avoid transposing errors when writing and entering data, and should be sure that all data are clearly legible. Practitioners should be in the practice of making photocopies of data sheets, and designating a copy as the Master Copy. The Master Copy can be edited by reviewers using red ink who should initialize and date any edits. Future copies of the Master Copy should either be made in color or clearly show these post-survey edits.

Data Analysis

This section is currently under development by the ISEMP Data Management Team and will be included in the next revision of this working version.

Data Reporting

The data collection agencies are responsible for preparing an annual report that will follow the procedures below covering the monitoring period. Guidelines for preparing the report can be found at http://www.efw.bpa.gov/Integrated_Fish_and_Wildlife_Program/ReportingGuidelines.pdf. In addition, the Upper Columbia Data Steward is responsible for generating an annual summary of water quality metrics by tributary and subbasin to the Watershed Action Teams, Project Sponsors and monitoring agencies.

1. Brief abstract (limit 600 words).
2. Standard introduction provided by ISEMP plus brief description of specific project(s) covered in report.
3. Concise description of project area/map.
4. Description of methods and materials used to perform tasks.
5. Summary of results. For example, summary of water quality data by location, e.g., number of days data collected, period of data collection, number of days temperature exceeded limits, daily mean pH, etc.
6. If necessary, supplemental electronic copies of summarized field data in spreadsheet or GIS format.

The annual report shall be submitted to the BPA Project Manager/COTR and the ISEMP coordinator.

Section 5: References

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Appendix A: Attribute Table

This section is under development by the ISEMP Data Management Team and will be included in the next working version.

Appendix B: Datasheets

2008 ISEMP Water Quality Grab sample datasheet							
Site #							
1	DCE						
	Site name						
	Date			Time			
	Temp	^{0}C	pH		Turbidity		NTU
	Weather		DO		Specific Conductivity		
2	DCE						
	Site name						
	Date			Time			
	Temp	^{0}C	pH		Turbidity		NTU
	Weather		DO		Specific Conductivity		
3	DCE						
	Site name						
	Date			Time			
	Temp	^{0}C	pH		Turbidity		NTU
	Weather		DO		Specific Conductivity		
4	DCE						
	Site name						
	Date			Time			
	Temp	^{0}C	pH		Turbidity		NTU
	Weather		DO		Specific Conductivity		
5	DCE						
	Site name						
	Date			Time			
	Temp	^{0}C	pH		Turbidity		NTU
	Weather		DO		Specific Conductivity		

Appendix C: Field Gear List

- ☐ Devices such as rebar, aircraft cables, locks, and/or diver's weights with which to secure loggers to streambed
- ☐ Surveyors marking tape
- ☐ 2-pound sledge hammer
- ☐ Wire cutters or pocket knife
- ☐ Temperature recording equipment requirements (silicone rings, submersible cases, silicone grease, silica packets)
- ☐ Portable computer and interface as needed by the temperature recorder if downloading and launching will be completed in the field
- ☐ Backup batteries and temperature recorders
- ☐ Timepiece
- ☐ Field book
- ☐ Waders
- ☐ Camera and film
- ☐ Machete or other brushing equipment
- ☐ Maps and aerial photos
- ☐ Wood or metal stakes or spikes
- ☐ Global Positioning System Device
- ☐ First aid kit and personal ID
- ☐ Three-pronged garden cultivator mounted on a 4-foot long wooden handle to recover dataloggers from deep water.

Appendix D: Protocol Revision Log

As new information becomes available and water quality monitoring efforts are refined, the protocol will be revised. Effectively tracking past and current protocol versions are important for data summaries and analyses that utilize data collected under different protocol versions. Protocol Editor will house previous and current protocol versions and the dates of their implementation. Reviews will be performed for all proposed changes to the protocol and the Upper Columbia Data Steward notified so the version number can be recorded in the project metadata and any necessary changes can be made to database structure (Peitz et al. 2002). Consistent with the recommendations of Oakley et al. (2003) this protocol includes a log of its revision history. The revision history log (adapted from Peitz et al. 2002) will track the protocol version number, revision dates, changes made, the rationale for the changes, and the author that made the changes. Revisions or additions to existing methods will be reviewed by ISEMP staff prior to implementation. Major revisions such as a complete change in methods will necessitate a broader review by outside technical experts. When the protocol warrants significant changes the protocol version and date on the title page should be updated to reflect the new version. Version numbers should increase incrementally by hundredths (e.g., Version 1.01, 1.02 etc.) for minor changes and by the next whole number (e.g., version 2.0, 3.0 etc.) for major changes (Peitz et al. 2002).

Protocol Revision History Log

Previous Version #	New Version #	Revision Date	Author	Changes Made	Reason for Change

(adapted from Peitz et al. 2002)